EXPLORING THE TECHNICAL REQUIREMENTS OF VACUUM GLAZING FOR CONTEMPORARY WINDOW CONSTURUCTIONS

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INTRODUCTION

Vacuum glass has been considered as a potential solution for energy-efficient transparent building assemblies. In recent years, the industrialized production of vacuum glazing has become more common. It can be expected that such products will be more frequently deployed in the building sector. Previous efforts in research and development mainly focused on the development of the vacuum glass itself, due to the challenges regarding durability of the glass (specifically, long-term preservation of vacuum in the interstitial space). Less attention has been paid to the construction detailing of windows equipped with vacuum glass. The properties of vacuum glazing are different from those of regular insulation glass. Thus different approaches to window construction are required. This contribution presents the structure and findings of a recent research project, focusing on design and construction of windows with vacuum glazing. Thereby, various performance aspects of different frame/glass constructions were examined. The thermal performance, one of the research foci within this project, was assessed in a two-fold manner: On the one hand, knowledge of previous studies pertaining to vacuum-glass application in historic window constructions was obtained and processed. On the other hand, numeric thermal bridge simulation was applied to evaluate different frame designs and to derive their performance indicators. Moreover, in the framework of the project, different innovative window detailing approaches were explored using simulation and functional prototypes. This contribution provides an overview of the research project, developed window construction designs, and their performance.

VACUUM GLASS

The term vacuum glass denotes here two glass panes with an interstitial distance of 0.15 to 0.5 mm and a tight edge seal around the component. Additionally, the interstitial space has a grid of distance holders (so called pillars) that keep the distance between the two glass panes. This is important, as the interstitial space is evacuated via an opening that is later sealed. Without the pillars the two glass shells would bend against each due to the surrounding atmospheric pressure. As this solution radically reduces conductive and convective heat transfer, the glass is highly insulating. Conduction occurs in the edge seal and through the distance pillars. Convection is practically eliminated, as long as the vacuum layer persists. The third heat transfer mechanism – radiation – is not affected by the evacuation. However, via application of low-emissivity foils, radiative processes could be influenced as well. Given the described setup, it seems clear that the edge seal and the pillars would represent potentially weak spots in the construction. In a previous study [1], the effect of the pillars regarding heat conduction was found to be very small, due to their very small dimension. Thus, the appropriate consideration of the edge seal in window construction forms the most important thermally relevant requirement for windows employing vacuum glazing pertaining to thermal performance.

WINDOW CONSTRUCTION WITH VACUUM GLAZING

During the past decades, the window industry in central Europe has contributed to a number of innovations in window construction. These include the introduction of double and triple glazing, the application of low-emissivity layers, the introduction of rubber seals, and the utilization of different construction materials, such as aluminium (as weatherproofing for timber frames). However, the fundamental construction principles regarding frame construction and operation possibilities (usually turn-and-tilt windows that open inwards) have not fundamentally changed. The introduction of vacuum glazing can be considered as an opportunity to new and innovative solutions. In the research project MOTIVE, different new window construction options with vacuum glazing were designed and extensively studied. Thereby, multiple issues were addressed, including construction possibilities, thermal and acoustical performance, usability, operability, and aesthetics. Specifically, seven design concepts were examined at different levels, ranging from conceptual sketches to full-fledge window mock-ups. Figure 1 illustrates a number of such concepts and associated level of investigation.

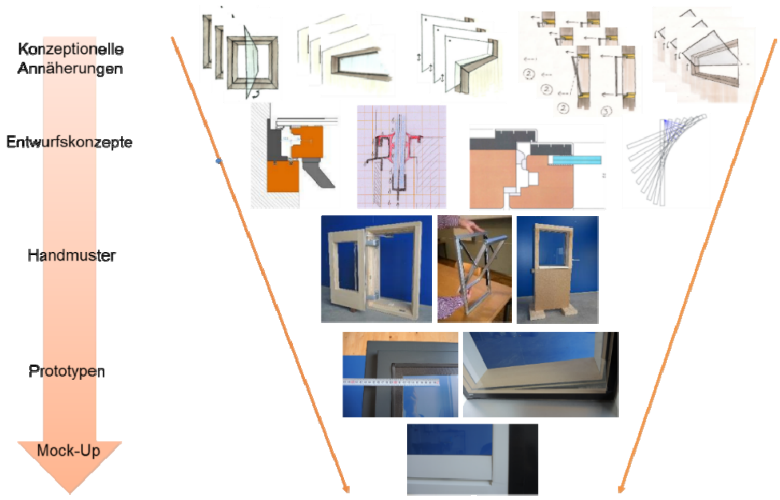

Figure 1: Examined window design ideas (and investigation depth).

RESULTS & CONCLUSION

The main results of the project suggest that, given the availability of construction fittings and seals, the proposed designs could be developed into windows with a performance matching those of common triple glazing windows, but superior in view of assembly thickness and weight. Some of the designs showed advantages in handling and maintenance (cleaning), while for other design ideas these aspects are not fully resolved. The resulting vacuum glazing prototypes encouraged the authors to initiate a research and development effort initiative together with key partners from window industry toward high-performance market-ready window products incorporating vacuum glass.

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